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IMPACT OF P FERTILIZER, LIME, AND GYPSUM APPLICATION ON STARGRASS YIELD AND QUALITY, AND ON SURFACE AND GROUND WATER QUALITY

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RESUME

Les signes d'augmentation dénotent que les concentrations du phosphore dans les eaux de surface sont le premier facteur contrôlant l'enrichissement en phosphore du lac Okeechobee et des autres cours d'eau en Floride. En plus la fertilisation de pâturage est perçue comme l'une des sources de niveau de phosphore élevé dans les eaux de surface. Une expérience au champ de trois ans a été conduite dans un ranch de la région d'Okeechobee en Floride, pour évaluer les effets des différentes proportions de phosphore sur les rendements et la qualité du stargrass afin de voir si les doses recommandées de l'université en ce qui concerne l'utilisation des engrais courants pourraient être réduites sans affecter la production et la qualité du pâturage. L'étude a aussi évalué les effets des niveaux de phosphore sur la qualité de la terre et de l'eau de surface. Les résultats de cette étude ont montré que les rendements et la qualité du stargrass n'étaient pas affectés par le phosphore. La qualité de l'eau a été améliorée à mesure que les proportions de phosphore décroissaient. Cette étude indique que les doses de phosphore pour le stargrass pourraient être réduites sans en affecter la production. Cela économiserait de l'argent pour les propriétaires de ranch aussi bien quant aux coûts de l'engrais, qu'en aidant à améliorer la qualité de l'eau.

ABSTRACT

Phosphorus fertilizer did not increase stargrass forage yield nor improved forage crude protein or forage digestibility when applied to an Immokalee fine sand soil (sandy, siliceous, hyperthermic Arenic Alaquod). Although the applied P improved forage tissue P concentration, most cattle producers routinely feed a balanced mineral salt which contains adequate P. Applied P caused a significant build-up of P in the Ap, E, and Bh horizons, increased soluble P concentrations in shallow and deep wells by 400% and 1500%, respectively, and in surface runoff by 50% and increased the potential for non-point source of P pollution. Gypsum was effective in eliminating P leachate from applied P into deep wells but was not beneficial for reducing P in surface runoff. Although promising in reducing total P in surface runoff, the long-term benefit of Ca-lime was not clear due to equilibrium effect.

INTRODUCTION

Phosphorus (P) is regarded as the primary cause of eutrophication or algae blooms of fresh water bodies or lakes in south central Florida. Excessive P fertilization on pastures may contribute to the problem (Sumner *et al.* 1989). This is supported by work conducted by Dr. Jack Rechcigl and his team (Rechcigl *et al.*, 1990; Rechcigl and Bottcher, 1995), which was funded by the South

Florida Water Management District. That study also showed that P fertilizer rates on bahiagrass could be drastically reduced without any adverse effect on bahiagrass forage yield and quality. In addition, P levels in surface water runoff were reduced by 33 to 60% as P fertilizer rates were decreased from 48 to 12 kg P ha⁻¹. Those studies led the Institute of Food and Agricultural Sciences (IFAS) of the University of Florida to adopt a zero P recommendation in 1998 for bahiagrass pastures grown south Florida.

The recommended P rate for improved pasture grasses other than bahiagrass, including stargrass (*Cynodon species*) still ranged from zero P to 20 kg P ha⁻¹ for high and low P soils, respectively (Kidder *et al.*, 1998). However, as demonstrated by Rechcigl and Bottcher (1995), fertilization of pastures even at the optimum P recommended rates could cause significant elevation of P levels in surface water runoff. Thus, in addition to establishing optimum rates of P fertilization for improved pasture grasses, it became necessary to evaluate the capacity of soil amendments for tying up fertilizer-derived P.

OBJECTIVES

The purpose of this study was to: 1) re-evaluate the existing IFAS recommended P fertilizer rates for stargrass and 2) study the effectiveness of limestone and gypsum for improving the retention capacity of soils for P fertilizer that was applied to stargrass pastures.

MATERIALS AND METHODS

A field experiment was conducted on a stargrass beef pasture at Williamson Cattle Company in the Lake Okeechobee Basin at Okeechobee, FL. Treatments (Table 1.) consisted of 0, 12.5, 25.0, 50.0 kg P ha⁻¹ from triple super phosphate applied to the stargrass pasture every year. The amendments consisted of calcium carbonate (CaCO₃) and mined gypsum (CaSO₄·2H₂O) applied based on 100% CaCO₃ at 0, 2.24 and 4.48 Mg ha⁻¹ every year to plots that received 50 kg P ha⁻¹. Each combination of P and soil amendment treatment was applied to a 50 x 100 ft plot replicated four times. All plots including the control received one uniform application of 74 kg K ha⁻¹ as KCl and two equal applications of 90 kg N ha⁻¹ as ammonium nitrate, yearly. Forage was sampled for dry matter yield, crude protein (CP) content, in vitro organic matter digestibility (IVOMD) and tissue mineral content once every 30-35 days. Forage was harvested seven times in 1999 and six times each in 2000 and 2001. Soil was sampled before the beginning of the experiment and in August 1999, March 2000, October 2000, and March 2001 from the surface down to the spodic layer at 15-cm depth interval, dried and analysed for Mehlich 1 extractable nutrients and various P fractions. A fully automated weather monitoring network was set up at the site to measure rainfall, surface runoff volume, and depth of water table. Water samples from surface runoff and from shallow PVC wells installed to 0.625 and 1.25 m depths inside plots were collected, depending on rainfall and water availability, for water quality analysis.

RESULTS AND DISCUSSION

Forage Yield and Quality

Phosphorus fertilizer application did not increase stargrass forage yield (Figure 1), did not improve forage crude protein content (CP) (Figure 2A) nor IVOMD (Figure 2B). This was due in part to a high initial soil P status and also in part to recycling of P from manure of grazing cattle.

The soil Ap horizon had an initial pH of 4.4 and there was an indication that stargrass yield from the control, which received N and K fertilizer could benefit from Mg via gypsum application only in the first year (Figure 1) but lime amendments to the soil had no effect on forage CP and IVOMD.

Phosphorus uptake by forage increased by 0.003% units for each kg P ha⁻¹ applied to pasture over the three year period. Fertilizer P also increased Ca uptake by 0.001% units per kg P ha⁻¹. However, neither P nor calcium carbonate had any effect on tissue K and Mg. Both calcium carbonate and gypsum had no effect on tissue P even at the highest liming rate of 4 Mg ha⁻¹ suggesting that the 50 kg P ha⁻¹ that was applied was not tied up but stayed readily available for plant uptake. Gypsum linearly increased stargrass tissue Ca at the rate of 0.012% but reduced tissue Mg by 0.007% at 50 kg P ha⁻¹. Averaged over three years, fertilizer P showed no effect on stargrass tissue Cu, Fe, Mn, and Zn. Calcium carbonate and gypsum also had no effects on stargrass tissue Cu, Fe and Zn. However, Calcium carbonate decreased whereas gypsum increased tissue Mn linearly.

Soil phosphorus status

Soil phosphorus fractionation indicated a relatively high initial total P in the Ap (375-495 ppm), E (28-48 ppm) and Bh (527-825 ppm) horizons of Immokalee fine sand. Phosphorus fertilization resulted in additional build up of soil P by 0.70 kg P for each kg of fertilizer P ha⁻¹. However, there was no agronomic benefits to this increase in soil P but rather increased potential for non-point P loss through surface runoff.

Soil water quality

The soluble phosphorus (ortho-phosphorus, OP) content in water samples was typically 85 to 95% of total phosphorus (TP). In 2001 when sufficient rainfall occurred, the OP concentrations increased significantly in shallow wells from less than 1000 to 5000 parts per billion (ppb), in deep wells from 0 to 1500 ppb, in surface runoff from 1000 to 1500 ppb as P fertilizer rates increased from 0 to 50 kg ha⁻¹. (Figure 3a). Corresponding increases in groundwater total P (TP) concentrations in response to applied P in 2001 were: in shallow wells from 1000 to 3000 ppb, in deep wells no effect, and in surface runoff from 800 to 900 ppb (Figure 3b). At 50 kg applied P ha⁻¹, increasing rate of gypsum from 0 to 4 Mg ha⁻¹ tied up the P and totally eliminated OP and TP from deep wells (Figure 4a and 4b) whereas increasing rate of calcium carbonate caused a slight increase of OP in surface runoff (Figure 5a) but a 40% decrease in TP concentration of surface runoff (Figure 5b).

CONCLUSION

Phosphorus fertilizer did not increase stargrass forage yield nor improved forage crude protein or forage digestibility. Although applied P improved forage tissue P concentration, most cattle producers routinely feed a balanced mineral salt which contains adequate P. Applied P caused a significant build-up of P in the Ap, E, and Bh horizons, increased soluble P concentrations in shallow and deep wells by 400% and 1500%, respectively, and in surface runoff by 50%. Gypsum was effective in eliminating P leachate from applied P into deep wells while Ca-lime marginally reduced TP in surface runoff.

This study collaborates results from another multi-county fertilizer study (Adjei et al 2000) to provide strong evidence that current IFAS P-fertilizer recommendations for all improved grasses of up to 20 kg P ha⁻¹ could be further reduced at no cost to forage production. The spodic soils in south-central Florida are generally high in P and when combined with P recycling from grazing cattle, pastures on those soils will produce well over long periods without any applied P. This will ultimately result in tremendous savings to ranchers as well as have a beneficial effects on groundwater quality. Attempts are being made to get current university of Florida-IFAS P fertilizer recommendations for stargrass modified based on this study.

ACKNOWLEDGMENT

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Table 1. Phosphorus treatments and amendment rates based on 100% CaCO_3 or $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ content

Treatment	P rates	Calcium carbonate	Mined gypsum
	----- kg P ha^{-1} -----	----- Mg ha^{-1} -----	
T1	0.0	0	0
T2	12.5	0	0
T3	25.0	0	0
T4	50.0	0	0
T5	50.0	2.24	0
T6	50.0	4.48	0
T7	50.0	0	2.24
T8	50.0	0	4.48

Figure 1 : Annual and 3-year mean dry matter yield of stargrass pasture on Immokalee fine sand as affected by P fertilizer with or without yearly Ca amendment.

There were 7 harvests in 1999 but 6 harvests each in 2000 and 2001. Bars with the same letter are not different ($P>0.05$) according to the Turkey's Student Range Tests.

NS= not significant ($P>0.05$)

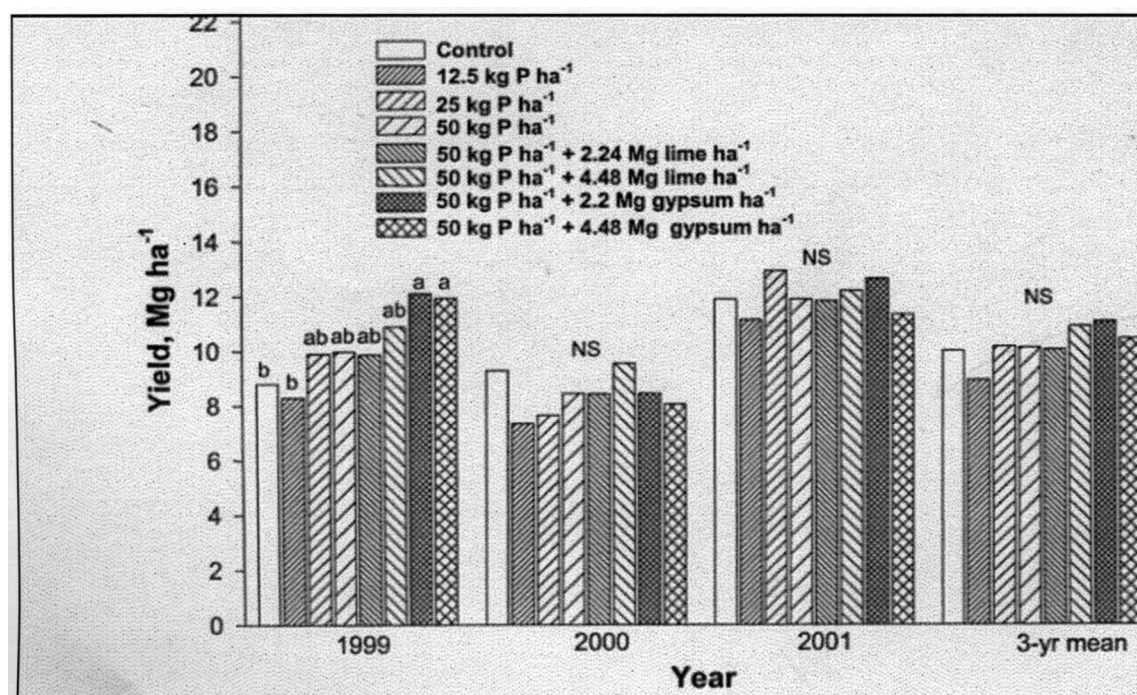


Figure 2 : Annual and 3-years mean crude protein (A) and IVOMD (B° of stargrass pasture on Immokalee fine sand as affected by P fertilizer without yearly Ca amendment.

There were 7 samples in 1999 but 6 samples each in 2000 and 2001.

NS=no significant difference ($P < 0.05$)

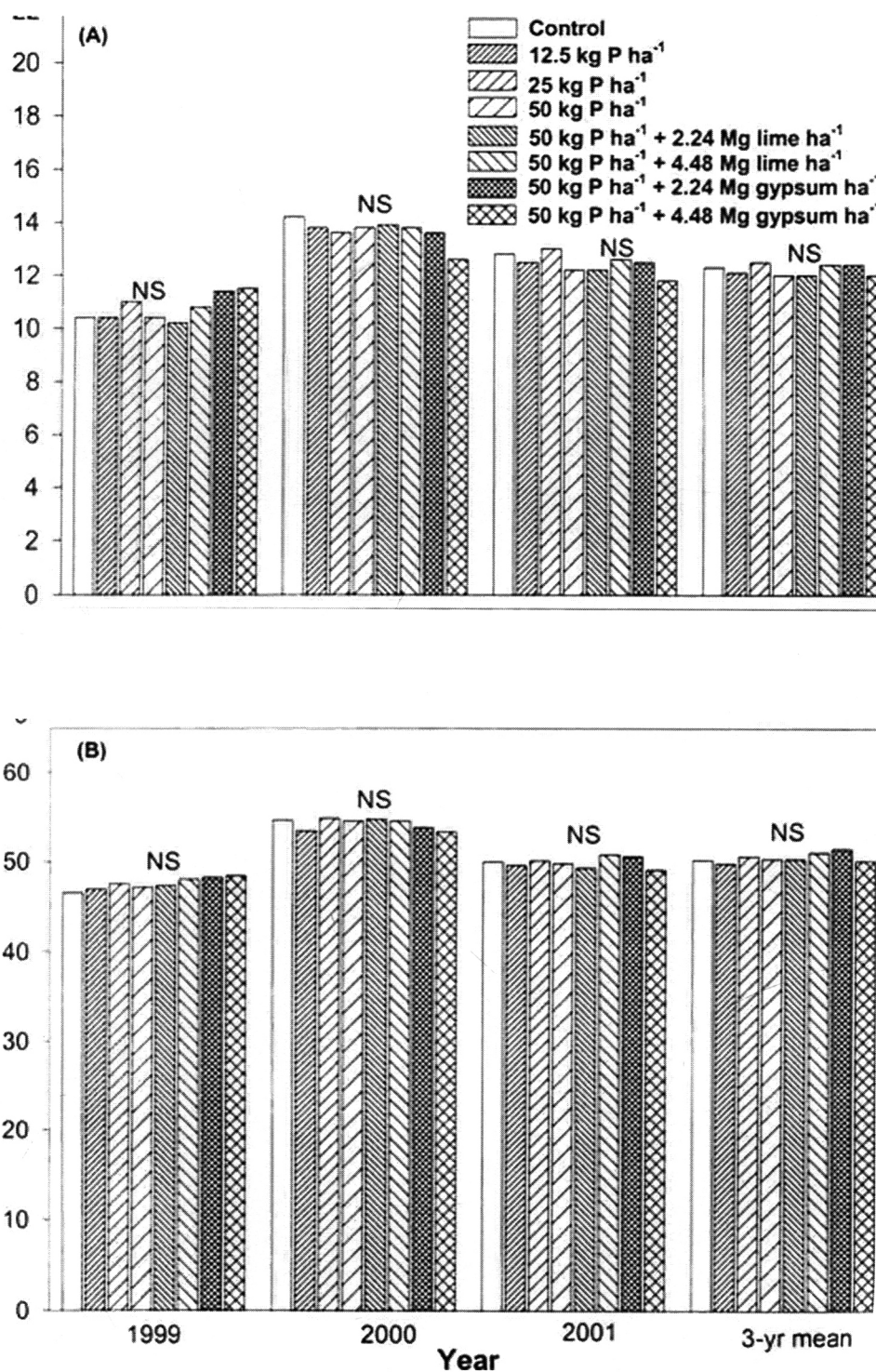


Figure 3. The influence of fertilizer-applied P on ortho and total P concentrations in groundwater and surface runoff

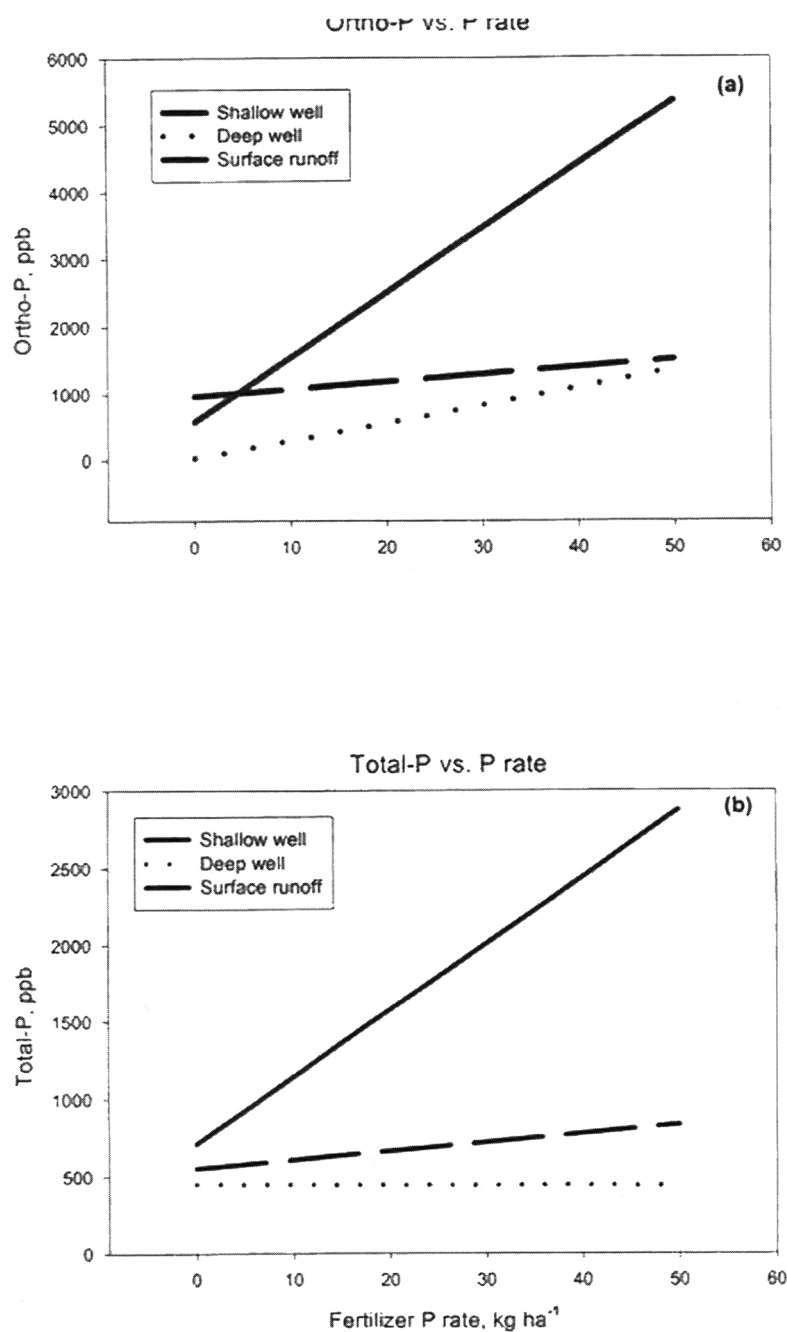
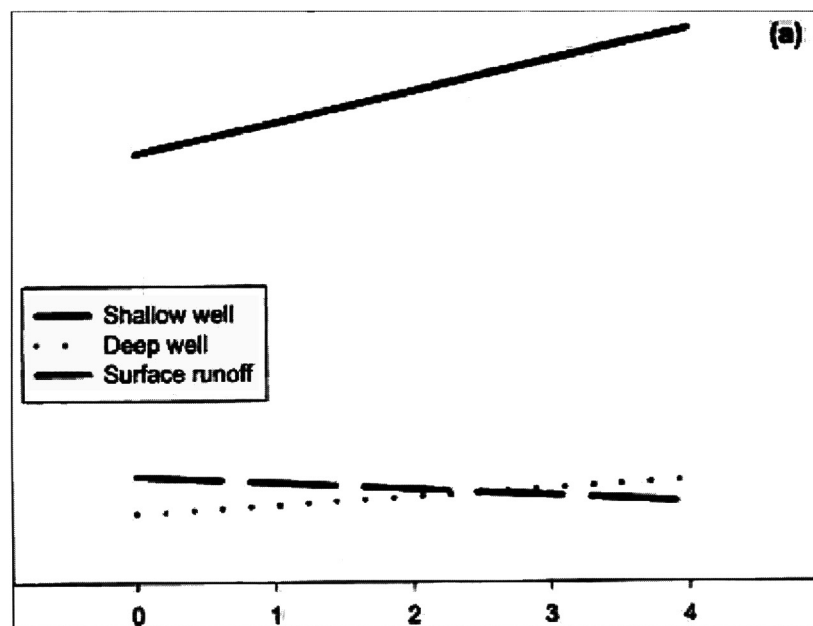


Figure 4. The influence of Calcium carbonate amendment on ortho and total P concentrations in groundwater and surface runoff

Ortho-P vs Ca-lime rate



Total-P vs. Ca-lime rate

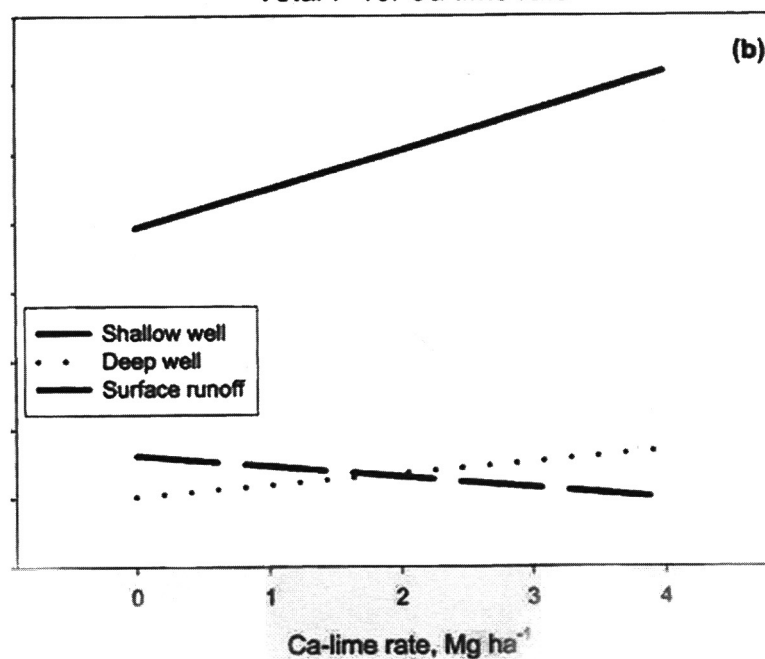


Figure 5. The influence of gypsum amendment on ortho and total P concentrations in groundwater and surface runoff

